

## FIVE-MICRON PICTURES OF JUPITER\*

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### ABSTRACT

More than 440 five-micron "video" pictures of Jupiter with 1" resolution were made during 1973 September, October, and December. Comparisons of these pictures with color photographs show direct, detailed correlations with the darker "purple" features. Forty-four of these pictures were made just before *Pioneer 10* encounter.

*Subject headings:* infrared — Jupiter

### I. INTRODUCTION

We have recorded several hundred 1" resolution 5- $\mu$  "video" pictures of Jupiter during several nights in late 1973. Interspersed with the 5- $\mu$  pictures, we obtained Kodachrome photographs to allow a direct correlation with visual form and color.

This work is an outgrowth of a continuing program of study of the localized 5- $\mu$  flux (Westphal 1969, 1972; Owen and Westphal 1972). More recently Keay, Low, and Rieke (1972) and Keay *et al.* (1973) at the University of Arizona have made 5- $\mu$  maps of Jupiter with 5" and 3" resolution and compared these maps with the visual Jovian colors, confirming Westphal's (1969) observation that the flux was coming from the darker regions of the planet.

### II. OBSERVATIONS

The observations were made at the east-arm Cassegrain focus of the Hale 200-inch (5-m) telescope during 1973 September 13, 15, 16, 19, and 20 UT, 1973 October 11 UT, and 1973 December 3 and 4 UT. The seeing was generally less than the aperture size during the September observations, and the highest quality data were collected at that time. Five-micron pictures were made about every 3 minutes, and Kodachrome II photographs were made occasionally to monitor the visual appearance of the planet. Standard stars were observed periodically for calibration.

The addition of a "wobbling" Gregorian secondary to the 200-inch and the development of an indium antimonide (InSb) detector system has allowed very large improvements in signal-to-noise ratios for astronomical measurements short of 6  $\mu$ .

A 12-inch diameter f/72 Gregorian mirror arranged to move the image N-S in the focal plane was mounted above the prime focus of the 200-inch Hale telescope. This mirror is servo driven to accurately reproduce any

arbitrary electrical input wave form as long as the acceleration is less than  $10^5$  arc min  $s^{-2}$  and the amplitude is less than 4'.

For these observations the mirror was moved with a staircase wave form of 128 steps, each 10 ms long, with a 80-ms flyback. This moved the image of Jupiter in 0.5 steps past a 1" circular focal-plane aperture in 1.28 s. By properly changing the right ascension rate of the telescope, a  $128 \times 128$  pixel area was scanned in 163.8 s.

The flux passing through the aperture was detected by a liquid-nitrogen-cooled photovoltaic InSb detector behind a cold 4.6–5.1  $\mu$  interference filter. Since the detector system has a short time constant and since the low-frequency noise from both the detector and the sky is small, these measurements were done in a d.c. mode without high-speed chopping.

The data were computer processed to correct for the slow background drifts and reformed to  $256 \times 256$  pixels to produce an output magnetic tape compatible with the SIT vidicon playback system described by Westphal (1973).

### III. DISCUSSION

Figure 1 (plates L4 and L5) shows four different longitude regions of Jupiter during 1973 September. Both photographic and contoured reproductions are shown to allow detailed examination of the data.

As was noted by Westphal (1969), the 5- $\mu$  flux is strongly localized and varies dramatically over regions at least as small as the resolution of our data. These new data, however, show that localized flux occurs over much of the planet, even in the polar regions and that almost all the flux seen outside three major belts (the NEB, SEB, and STeB) is emitted in areas smaller than the 1" resolution of the data. The lower-resolution maps of Keay *et al.* (1973) show these local areas, but it is not clear from their data that the spots are so small and isolated.

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## PLATE L4

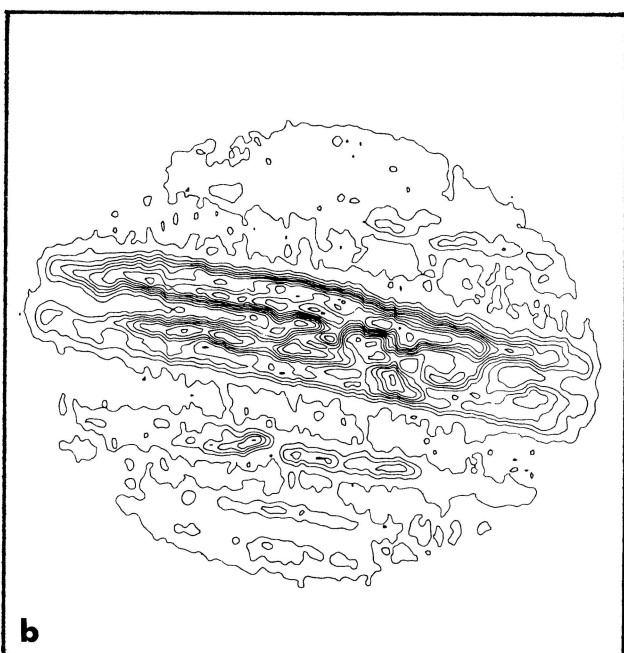
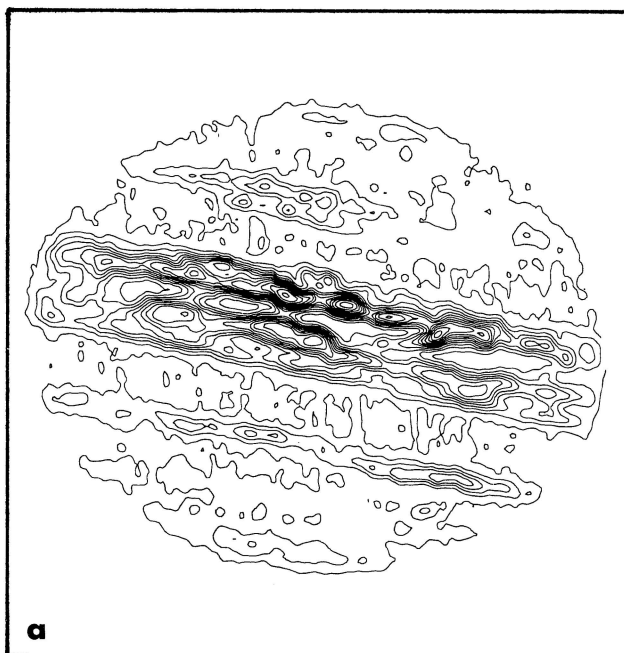
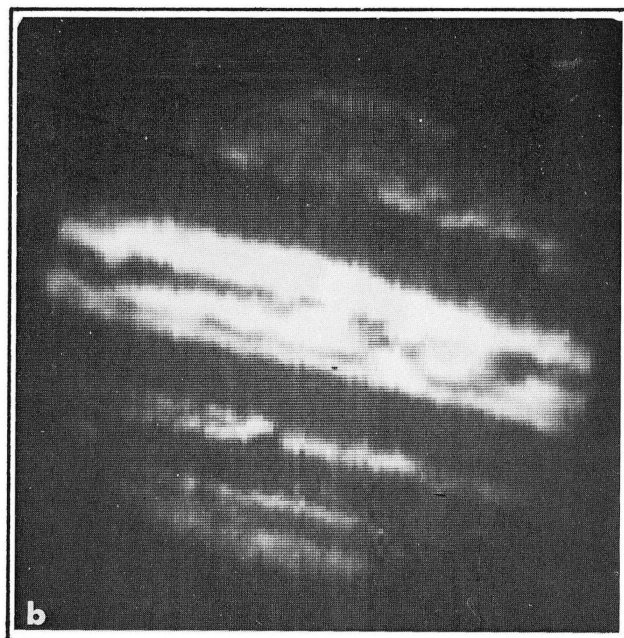
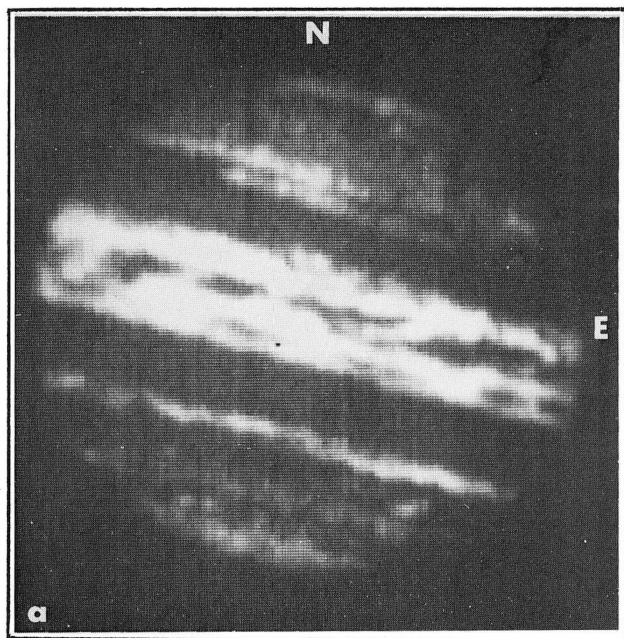


FIG. 1(a)—5-micron photograph and contour map of Jupiter recorded on 1973 September 20, 4<sup>h</sup>02<sup>m</sup> UT.  $\lambda_I = 221^\circ.7$ ;  $\lambda_{II} = 345^\circ.8$ .  
 (b) Same on 1973 September 20, 6<sup>h</sup>30<sup>m</sup> UT.  $\lambda_I = 313^\circ.1$ ;  $\lambda_{II} = 76^\circ.4$ .

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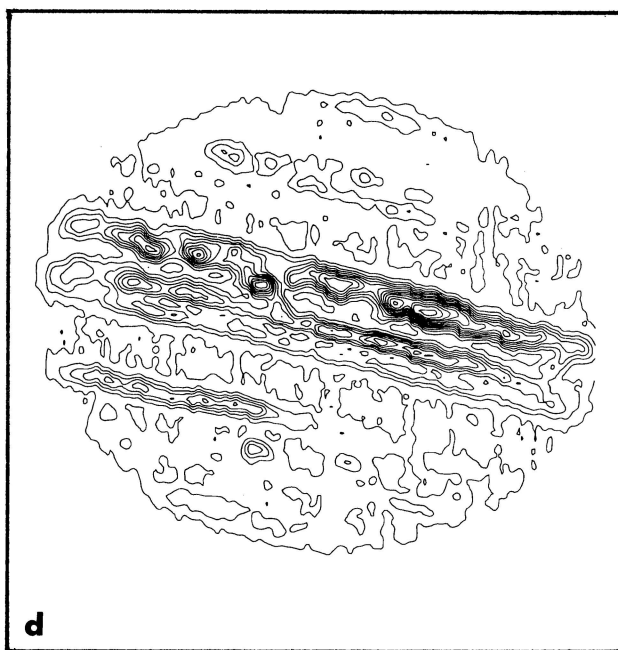
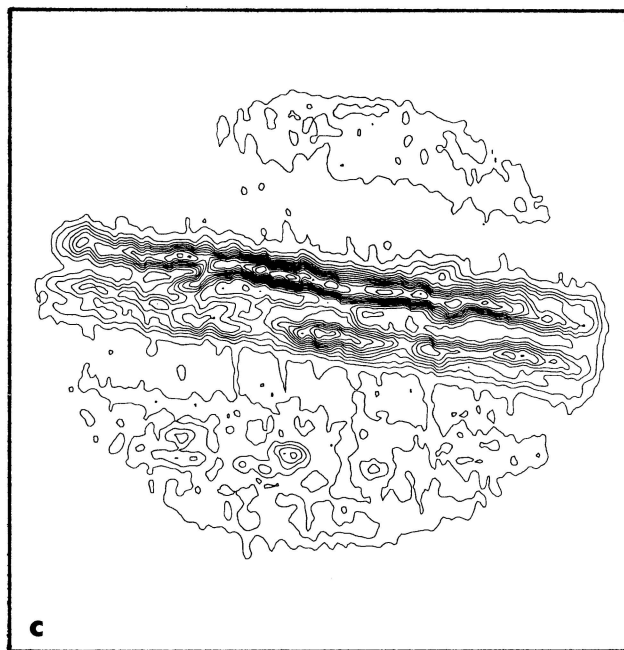
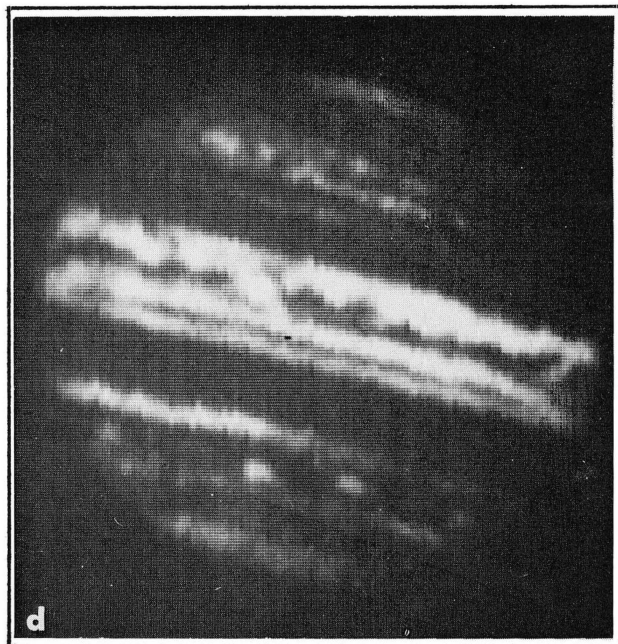
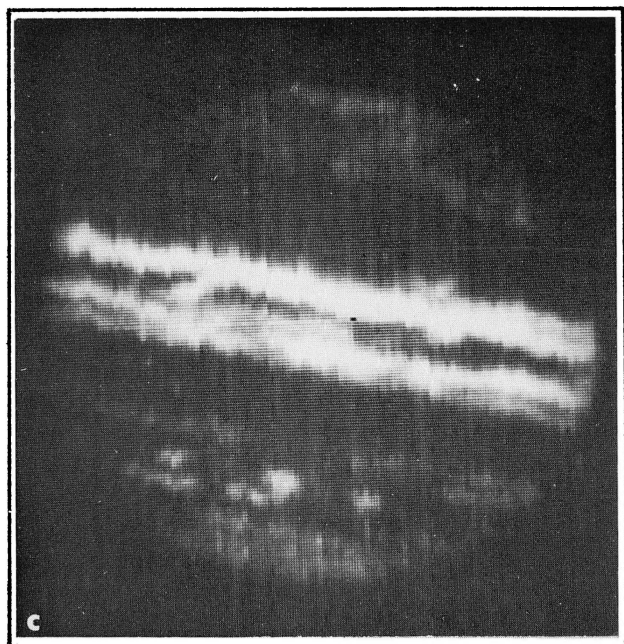


FIG. 1(c)—Same on 1973 September 19, 3<sup>h</sup>07<sup>m</sup> UT.  $\lambda_I = 30^\circ 8'$ ;  $\lambda_{II} = 162^\circ 9'$ . (d) Same on 1973 September 19, 5<sup>h</sup>32<sup>m</sup> UT.  $\lambda_I = 118^\circ 6'$ ;  $\lambda_{II} = 249^\circ 9'$ . The contour maps have linear contour levels and are not geometrically rectified.

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Of further interest is the correlation of  $5\text{-}\mu$  features with visual features on the color pictures. Keay *et al.* (1973) have compared their low-resolution data with color pictures and find a strong correlation of flux with "blue" features. With the increase in resolution, it is now clear that the thermal flux comes almost entirely from "blue" or "purple" regions. Our results confirm the results found by Westphal (1969) and Keay *et al.* (1973) that orange and red regions, including the Great Red Spot, are not sources of  $5\text{-}\mu$  radiation.

It is very likely that the "blue" or "purple" regions of Jupiter are relatively clear of clouds which normally block the  $5\text{-}\mu$  flux from deep in the atmosphere and that the "blue" or "purple" color may represent low albedo, due to a lack of clouds, rather than a real color difference. It is important to note that the "orange" and "red" regions are really "minus blue" regions (Münch and Younkin 1964) in that their red albedo is similar to other regions of the planet, while their blue albedo is much lower. In contrast, the "blue" regions do have lower red albedos than the rest of the planet, as they should if they are regions of holes in the clouds.

On 16 September the shadow of Io crossed the disk as  $5\text{-}\mu$  scans were being collected. No change in the flux occurred as the shadow passed over the planet—a result conclusively establishing that the  $5\text{-}\mu$  flux is not reflected

or scattered sunlight from some unusual material with enhanced backscattering properties.

Perhaps the most important feature of the new data is the possibility of producing limb-darkening measurements for local spots over most of the surface of the planet. Limb-darkening data are the most likely to be useful for understanding the details of the flux emission and therefore both the horizontal and vertical cloud structure (Westphal 1972; Keay *et al.* 1973). We are now reducing the September data to produce limb-darkening curves for a large number of spots at several latitudes and will report these results later.

To furnish a set of  $5\text{-}\mu$  observations of the part of Jupiter viewed by *Pioneer 10* at encounter, 1973 December 4 UT, we recorded 44 five-micron pictures during the preceding afternoon under varying cloud and seeing conditions.

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